

MICROELECTRODES IN AN OPHTHALMIC ELECTROCHEMICAL SENSOR

BACKGROUND

[0001] Unless otherwise indicated herein, the materials described in this section are not prior art to the claims in this application and are not admitted to be prior art by inclusion in this section.

[0002] An electrochemical amperometric sensor measures a concentration of an analyte by measuring a current generated through electrochemical oxidation or reduction reactions of the analyte at a working electrode of the sensor. A reduction reaction occurs when electrons are transferred from the electrode to the analyte, whereas an oxidation reaction occurs when electrons are transferred from the analyte to the electrode. The direction of the electron transfer is dependent upon the electrical potentials applied to the working electrode by a potentiostat. A counter electrode and/or reference electrode is used to complete a circuit with the working electrode and allow the generated current to flow. When the working electrode is appropriately biased, the output current is proportional to the reaction rate, which provides a measure of the concentration of the analyte surrounding the working electrode.

[0003] In some examples, a reagent is localized proximate the working electrode to selectively react with a desired analyte. For example, glucose oxidase can be fixed near the working electrode to react with glucose and release hydrogen peroxide, which is then electrochemically detected by the working electrode to indicate the presence of glucose. Other enzymes and/or reagents can be used to detect other analytes.

SUMMARY

[0004] Some embodiments of the present disclosure provide an eye-mountable device including a transparent polymeric material, a substrate, an antenna, a two-electrode electrochemical sensor, and a controller. The transparent polymeric material can have a concave surface and a convex surface. The concave surface can be configured to be removably mounted over a corneal surface and the convex surface can be configured to be compatible with eyelid motion when the concave surface is so mounted. The substrate can be at least partially embedded within the polymeric material. The antenna can be disposed on the substrate. The two-electrode electrochemical sensor can be disposed on the substrate. The two-electrode electrochemical sensor can include a working electrode having at least one dimension less than 25 micrometers, and a reference electrode having an area at least five times greater than an area of the working electrode. The controller can be electrically connected to the electrochemical sensor and the antenna. The controller can be configured to: (i) apply a voltage between the working electrode and the reference electrode sufficient to generate an amperometric current related to the concentration of an analyte in a fluid to which the eye-mountable device is exposed; (ii) measure the amperometric current; and (iii) use the antenna to indicate the measured amperometric current. A portion of the transparent polymeric material can surround the working electrode and the reference electrode such that an electrical current conveyed between the working electrode and the reference electrode is passed through the at least partially surrounding portion of the transparent polymeric material.

[0005] Some embodiments of the present disclosure provide a system including an eye-mountable device and a reader. The eye-mountable device can include a transparent polymeric material, a substrate, an antenna, a two-electrode electrochemical sensor, and a controller. The transparent polymeric material can have a concave surface and a convex surface. The concave surface can be configured to be removably mounted over a corneal surface and the convex surface can be configured to be compatible with eyelid motion when the concave surface is so mounted. The substrate can be at least partially embedded within the polymeric material. The antenna can be disposed on the substrate. The two-electrode electrochemical sensor can be disposed on the substrate. The two-electrode electrochemical sensor can include a working electrode having at least one dimension less than 25 micrometers, and a reference electrode having an area at least five times greater than an area of the working electrode. The controller can be electrically connected to the electrochemical sensor and the antenna. The controller can be configured to: (i) apply a voltage between the working electrode and the reference electrode sufficient to generate an amperometric current related to the concentration of an analyte in a fluid to which the eye-mountable device is exposed; (ii) measure the amperometric current; and (iii) use the antenna to indicate the measured amperometric current. A portion of the transparent polymeric material can surround the working electrode and the reference electrode such that an electrical current conveyed between the working electrode and the reference electrode is passed through the at least partially surrounding portion of the transparent polymeric material. The reader can include one or more antennae and a processing system. The one or more antennae can be configured to: transmit radio frequency radiation to power the eye-mountable device, and receive indications of the measured amperometric current via backscatter radiation received at the one or more antennae. The processing system can be configured to determine a tear film analyte concentration value based on the backscatter radiation.

[0006] Some embodiments of the present disclosure provide a method including applying a voltage between a working electrode and a reference electrode, measuring an amperometric current through the working electrode, and wirelessly indicating the measured amperometric current. The voltage applied between a working electrode and a reference electrode can be sufficient to cause electrochemical reactions at the working electrode. The working electrode and the reference electrode can be embedded within an eye-mountable device having a concave surface and a convex surface. The concave surface can be configured to be removably mounted over a corneal surface and the convex surface can be configured to be compatible with eyelid motion when the concave surface is so mounted. The working electrode can have at least one dimension less than 25 micrometers and the reference electrode can have an area at least five times greater than an area of the working electrode. The working electrode and the reference electrode can be arranged in the eye-mountable device such that the electrochemical reactions are related to a concentration of an analyte in a fluid to which the eye-mountable device is exposed. The amperometric current can be measured through the working electrode while the voltage is applied between the electrodes. The eye-mountable device can include a polymeric material with a portion that at least partially surrounds the working electrode and the reference electrode such that an electrical current conveyed between the